

cent. CaO. The orthosilicate is readily attacked by water, which dissolves out the lime in large quantities; this is probably the reason why it is not found as a natural mineral.

The three eutectics are:—(1) tridymite+metasilicate, 37 per cent. CaO, 1417° ; (2) metasilicate+orthosilicate, 54 per cent. CaO, 1430° ; (3) orthosilicate+lime, $67\frac{1}{2}$ per cent. CaO, 2015° .

Although the melting point of lime is unknown, the authors have been able to plot a complete diagram of the different equilibria that may occur in this series of compounds (Fig. 1). The importance of such an achievement can scarcely be overestimated, and there can be little doubt that it will play as important a part in the development of experimental mineralogy as Roozeboom's classical diagram for the iron-carbon steels has done in modern metallurgy.

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CHARACTER AND CAUSE OF SUN-SPOT SPECTRA.¹

IT is now just forty years since the selective widening of Fraunhoferic lines in sun-spot spectra was first observed by Sir Norman Lockyer. Since then various papers relating to the same subject have been published by Sir Norman Lockyer, Prof. Young, and—more recently—Dr. Mitchell and Prof. Hale.

The authors of the present paper state at the outset that in considering the chief features of sun-spot spectra, three points especially attract attention:—

(1) The fact that certain lines in the spectrum of a given element are strengthened, others are weakened, the remainder being unaffected.

(2) The occurrence of the strengthened lines in the visible spectrum only; none appear in the ultra-violet.

(3) The relatively great intensity of the continuous background of the spot spectra in the less refrangible region.

From what is known of laboratory spectra taken under varying temperature conditions, the following facts accrue:—

(1) That in passing from a high temperature to a lower one, certain lines are relatively strengthened, some are unaffected, and others are diminished in intensity.

(2) That such a reduction of temperature is accompanied by an increase in the relative intensity of the less refrangible lines, and a shift of the maximum of a continuous spectrum towards the red.

The general correspondence of these two groups of facts led the authors to seek for an explanation of the spectrum of sun-spots, on the hypothesis that the metallic vapours within the spots have a temperature lower than that of the photosphere.

Photographs of spot spectra, made with the Snow telescope and a Littrow spectrograph of 18 feet (5.5 m.) focal length, and showing a great number of affected lines, were available for the investigation. The range of spectrum covered by these photographs is from D to H β . Supplementary photographs of the spectra of recent large spots, extending from A in the red to the ultra-violet, have been obtained by Mr. Ellerman.

The laboratory work began with a study of iron and other metals in a synchronous rotating arc, designed and constructed by Prof. Crew, but as the necessary photographs involved undesirably long exposures this was not continued. It occurred to Mr. Gale to try the effect of varying the current strength in an ordinary 110-volt direct-current arc, the difference of potential between the poles being kept approximately constant. Photographs were taken, with currents of 30 amperes and 2 amperes, of the spectra of iron, titanium, vanadium, chromium, manganese, calcium, and other metals characteristic of sun-spots. As the work progressed, a correspondence was noted between the enhanced lines (lines stronger in spark than in arc) and those weakened in sun-spots. To get further light on this, photographs were taken of the spectra

of the same elements in the discharge of a 600-watt transformer, giving about 6000 volts at the secondary terminals. A condenser was used in the discharge circuit, and the potential was increased by an auxiliary air spark in series with the observed spark, both being exposed to a strong blast of air from an electric fan. Under these conditions the enhanced lines of the spark are well shown.

The instrument used to obtain the majority of the laboratory photographs was a grating spectroscope in the Littrow form of 13 feet (3.96 m.) focal length. The Michelson grating has 700 lines to the millimetre. In taking the comparison photographs of strong- and weak-arc spectra, two of the strong-arc spectra, with varying exposures, were generally placed on each side of the weak-arc spectrum. From the four different strong-arc exposures thus obtained that one was selected which was most nearly comparable in general strength with the weak-arc spectrum. In some cases the spark spectrum was added, adjoining the weak-arc spectrum, with the strong-arc spectra arranged as before.

Tables are given in the paper which contain the results of a study of the elements titanium, vanadium, iron, chromium, and manganese for the region extending from the ultra-violet to λ 5800. The tables include all the lines which are affected prominently, and which, being strengthened or weakened in spots, or in spark or weak arc as compared with strong arc, are of special importance in the investigation.

In discussing the behaviour of the lines of the elements mentioned, the investigation is divided into two parts, the relation of the weak arc to the strong arc, and of the arc to the spark. Two sets of tables are therefore given. The first shows the wave-lengths of all the lines which are much affected in spots, the amount by which they are affected, their behaviour in the weak as compared with the strong arc, and in the spark as compared with the weak arc. The second set of tables gives a comparison of the intensities of the lines of the same elements which are considerably enhanced in the spark, with their intensities in the weak arc. The majority of these which occur in the less refrangible part of the spectrum are weakened in spots, and such lines therefore appear in both sets of tables. As, however, most of the strongly enhanced spark lines occur in the violet and ultra-violet—the Fraunhoferic lines—-independent lists of these lines have been added, since the evidence afforded by them as to the relation of spark to weak arc is extremely important.

The authors summarise some of the results accruing from the investigation as follows:—

(1) More than 90 per cent. of the lines in the tables which are strengthened in sun-spots are found to be strengthened in passing from a 30-ampere arc to a 2-ampere arc.

(2) More than 90 per cent. of the lines shown by the tables to be weakened in sun-spots are weakened or absent in the 2-ampere arc.

(3) More than 90 per cent. of all the enhanced lines included in the tables are weakened or absent in the 2-ampere arc.

(4) In a list selected at random of 152 lines which are not spot lines, no cases were found of lines strengthened in the low-current arc.

In discussing the temperature hypothesis as the probable explanation of the observed phenomena, some of the points made are:—

(1) Waidner and Burgess's investigation of the temperature of the arc showed that the temperature of the crater was reduced 70° when the current was reduced from 30 to 15 amperes. As the relative intensities of the lines undergo no material change in passing from 30 to 15 amperes, while the change from 30 to 2 amperes is very pronounced, the temperature of the crater is probably considerably reduced at 2 amperes.

(2) Since the enhanced lines of the spark diminish in intensity in the 30-ampere arc, and are still further reduced in the 2-ampere arc, no explanation hitherto advanced to account for these lines appears adequate in the present case, unless it be the explanation based on change of temperature.

¹ Abstract of an advance proof from Mount Wil's Solar Observatory of a "Preliminary Paper on the Cause of the Characteristic Phenomena of Sun-spot Spectra." (Contributions from the Solar Observatory, No. 11.) By George E. Hale, Walter S. Adams and Henry G. Gale. The paper is to be published in a future number of the *Astrophysical Journal*.

(3) The behaviour in stars of the lines affected in sun-spots appears to be consistent with the view that temperature changes alone are sufficient to account for their variation in intensity. (In this connection the authors formerly were inclined to the view that the presence of sun-spot lines in the spectra of red stars indicated the presence of many spots like those on the sun. Recent work has led them to the opinion that the comparatively low temperature of these stars offers the simplest explanation of the observed phenomena. The latter opinion had previously been arrived at and published by Sir Norman Lockyer in a paper "On the Relation between the Spectra of Sun-spots and Stars."¹) In α Orionis—which from other considerations has been regarded as much cooler than the sun—lines that are strengthened in sun-spots are still further increased in intensity, and in Arcturus, which is always assumed to be intermediate in temperature to α Orionis and the sun, the intensities of its lines have been shown by Mr. Adams to agree remarkably with those observed in sun-spots.

In an addendum to the paper an account is given of further work with (1) the flame of an ordinary arc; (2) a modified form of a Moissan electric furnace.

It was found that the spectrum furnished by the flame of the arc—which is undoubtedly of a lower temperature than the core—showed changes of intensity similar to those observed with the 2-ampere arc and synchronous arc. Comparison of the lines affected in the flame with those affected in the weak arc showed that, of the lines of Ti, V, Cr, Fe, and Mn which were compared, nearly 90 per cent. were affected in the same direction, and of these latter the same proportion were affected to a like amount. Consequently, a large majority of the lines strengthened in sun-spots are relatively strengthened in the flame, while those weakened in sun-spots are relatively weakened in the flame.

The work with the electric furnace was done under conditions which, the authors state, eliminated all possible electrical effects, and left temperature as the only possible agent for producing any variations in intensity of the spectrum lines. Only Mn and Fe were investigated in this way, but the resulting spectra again showed great similarity to the weak-arc spectra, the majority of the lines being affected alike in the two cases.

At the end of the paper a few objections which can be laid against the temperature hypothesis are touched upon.

In a note added on October 2 an observation is included which seems to leave no doubt as to the comparatively low temperature of sun-spots. At least one of the titanium flutings which occur in the flame of the arc has been clearly demonstrated to be present in two of the best spot-spectrum photographs.

The work is regarded by the collaborators as being only at a preliminary stage, but it is evident that it will, with subsequent work on similar lines, have an important bearing, not only on the relative temperatures of sun-spots and photosphere, but also on the temperature classification of stars.

ANTHROPOLOGICAL NOTES.

O the second number of *Bulletins et Mémoires de la Société d'Anthropologie de Paris* (ser. 5, T. vii., 1906) Lieut. Desplagnes contributes an interesting paper on a little-known region of Central Nigeria, lying at the base of the plateau of Bandiagara (Banjagara), in the Massina district. This lake region seems to have been inhabited from the earliest antiquity, and in the Polished Stone period to have supported a dense population at a high grade of civilisation, to which numerous Megalithic monuments and a quantity of stone weapons and implements bear testimony; and long before our era examples of metal working, weaving, pottery, &c., show the industrial stage to which the inhabitants had attained. The character of the remains, physical and cultural, seem to suggest an Eastern origin for these early occupants, who were probably related to the ancestors of the Galla-Somali peoples. Later on, the nomad and pastoral peoples of the Sahara

¹ Roy. Soc. Proc., vol. lxxiv. p. 53.

attracted by the well-watered pastures, poured down from the north, and the tribes from the forests pressed up from the south; but all of these, though attaining right by might, had no aptitude for organised industry, and the primitive inhabitants were utilised as a sort of caste of workers, superior to slaves, but yet not mixing with the conquering clans. In the smiths, weavers, fishers, and potters, are found the descendants of the earlier owners of the land, while others maintained their independence by taking refuge in the islands in the river, the Sorkos, or in the surrounding mountains, the Habbès. The paper deals chiefly with the Habbès, describing their traditions, customs, habits, dwellings, industries, religious ideas, and sociology, in all of which they differ from their neighbours. The illustrations give an idea of the character of the country and the people, and the photographs of the masked figures in the religious dances, supposed to represent the Spirit of the Ancestors, are of particular interest.

L'Anthropologie, Tome xvii., 1906, contains the first instalment of a study by Dr. E. T. Hamy, "Les Premiers Gaulois." Dr. Hamy attempts to trace the physical characters of these invaders of northern Italy in the early Iron age from the evidence of the tumulus burials in France. The evidence is unfortunately very scanty, but it is worthy of note that the skulls in the neighbourhood of the forest of Châtillon have a cephalic index ranging from 80 to 84, with an altitudinal index of 88 to 93, although one skull from Banges, in the same district, has an index of 73.1. This is followed by a paper by Mr. Ed. Piette, "Le Chevêtre et le Semi-domestication des animaux aux temps pléistocènes," with many figures showing clear representations of halters in the engravings from the caves of Brassempouy, Mas d'Azil, &c. This communication forms the ninth in Piette's series of prehistoric ethnographic studies, and his last, for the volume ends with a notice of his death and a recognition of the great services which he has rendered to the science of prehistoric ethnography. The second part of "Les Restes humaines Quaternaires dans l'Europe Centrale," by Mr. H. Obermaier, continues the useful summary of the evidence for Quaternary man in Europe. The cautious tone of the writer is seen in the brevity of the list of human remains "sûrement quaternaires" when compared with the list of "Indications à écarter comme erronées, douteuses ou insuffisantes."

In *Globus*, lxxxix., Nos. 14 and 15, Mr. Vojtěch Frič gives an account of his travels along the Pilcomayo—a tributary of La Plata—in Central Chaco, with notes on the Pilagá and other Indians, and illustrations showing the character of the country and the fine-looking type of inhabitants. Among the majority of these tribes, it may be noted, the women propose marriage to the men, the *modus operandi* differing among the different groups. The method employed by the Pilagá women is to place a certain zigzag mark on a certain tree; the chosen man presents himself, and no further ceremony is needed. No. 17 contains a description, by Dr. Claus Schilling, of the Tamberma, who until a few years ago were an undiscovered people, near the borders of Togo. The illustrations taken by the author show the peculiar architecture and costumes of the district. This paper is followed by a short account of another African people, the Mpororo of the north-west corner of German East Africa, by Oberleutnant Weiss. Nos. 18 and 19 of the same periodical contain articles on the Gold Coast negroes by the medical missionary Dr. H. Vortisch, who gives a review (with illustrations) of their physical features, clothing, character, family life, sociology, political organisation, &c., and a careful record of their musical instruments, thirteen of which are figured. Mr. Erland Nordenskjöld contributes an article to *Globus*, lxxxix., No. 22, "Der Doppeladler als Ornament auf Aymarageweben," tracing the degeneration of the zoomorphic design through varying stages. In a series of papers (in Nos. 11, 20, 24, and xc., 1.) Dr. Theodor Koch-Grünberg describes his travels "Kreuz und Quer durch Nordwestbrasilien," giving excellent pictures of the scenery and of the natives, with a map to show the linguistic grouping. Of particular interest are the native drawings of animals. In xc., No. 4, W. von Bülow criticises the theories of Percy Smith, E. Tregears,